Unit 2

Part 2

Matter Exchange & Transfer

AP Biology

Mrs. Petrov

What is matter?

How is it different from energy?

What are the forms of matter & energy needed by…

Autotrophs?

Heterotrophs?

98% of the Atoms in Organisms…

- Sulfur
- Phosphorous
- Oxygen
- Nitrogen
- Carbon
- Hydrogen

- SPONCH

Identify the atoms found in each of the compounds below

Carbohydrates:

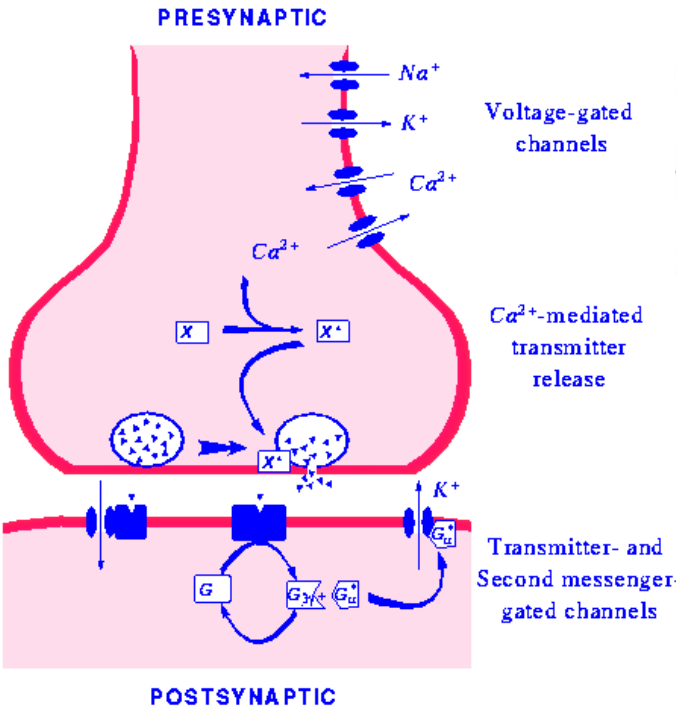
Lipids:

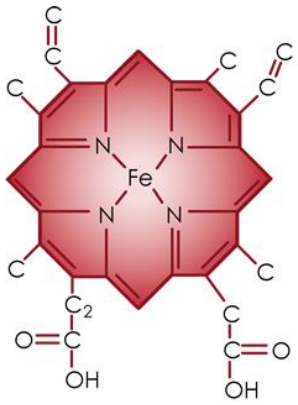
Proteins:

Nucleic Acids:

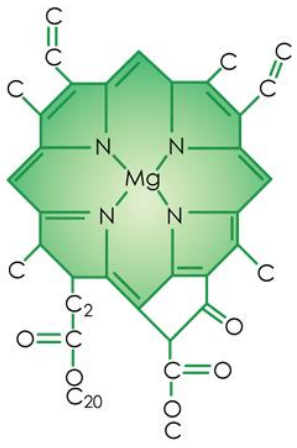
Important Elements in the other 2%...

- Calcium Ca^{2+}
- Sodium Na^{+}
- Potassium K^{+}
- Chlorine/Chloride Cl^{-}
- Magnesium Mg^{2+}
- Iron Fe^{2+}
- All used to maintain electrochemical gradients & Magnesium/Iron essential to pigments





Human Blood Hemoglobin

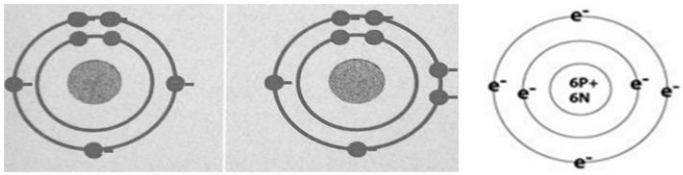


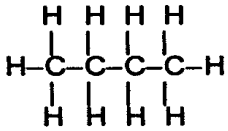
Plant Chlorophyll

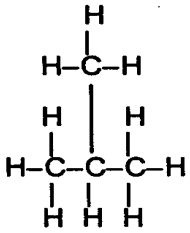
Carbon

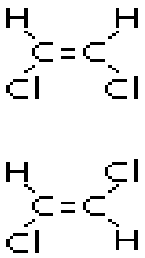
- Used in all compounds found in organisms
- Why is carbon so special?
- ***Tetra***valence: Forms 4 covalent bonds

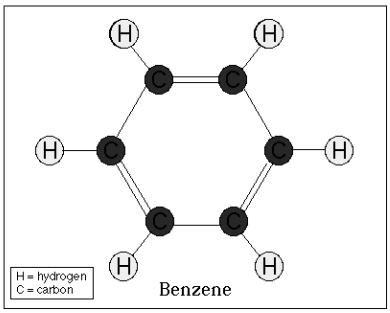
Nitrogen Oxygen Carbon

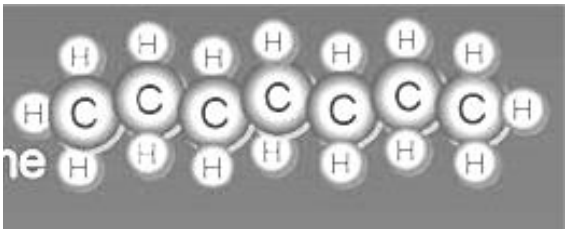


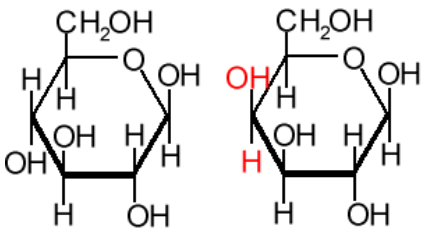


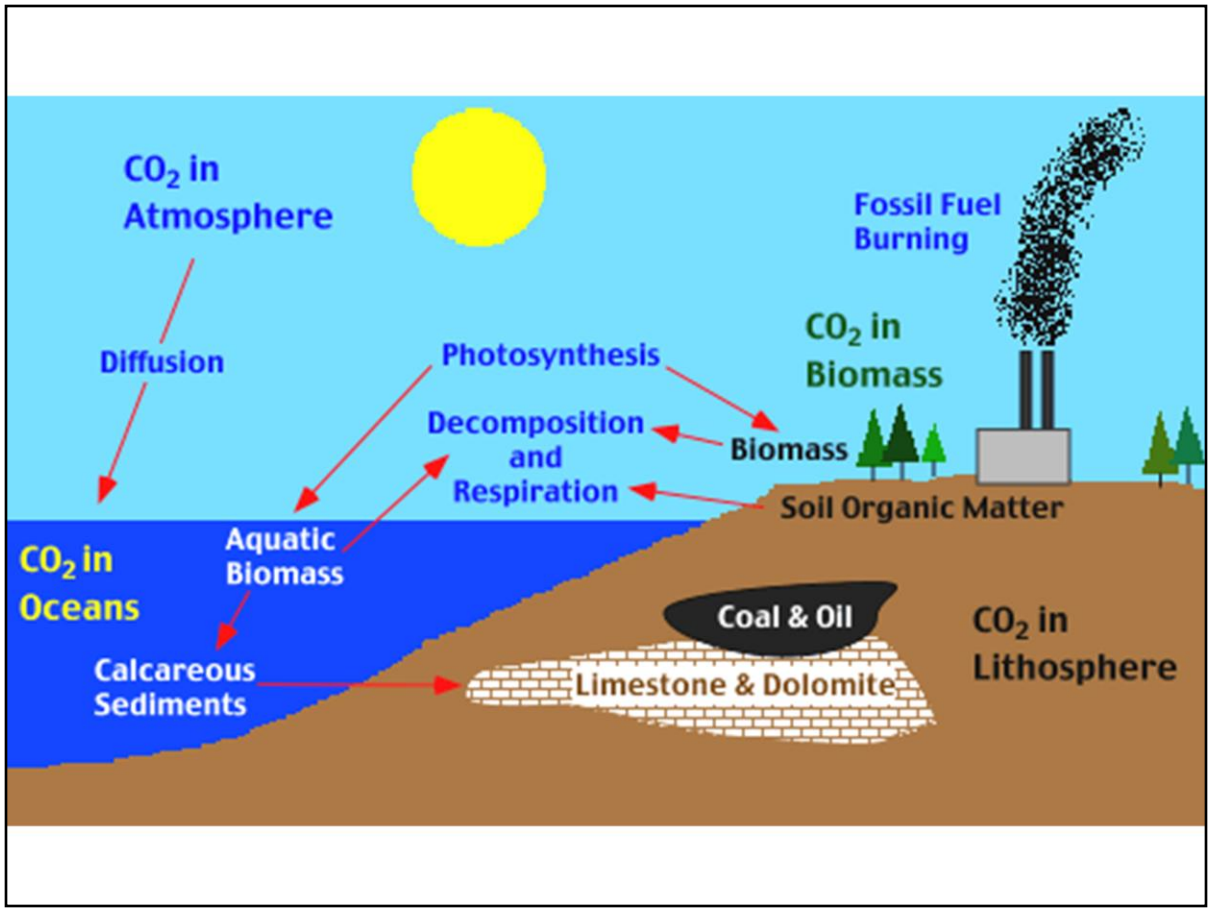












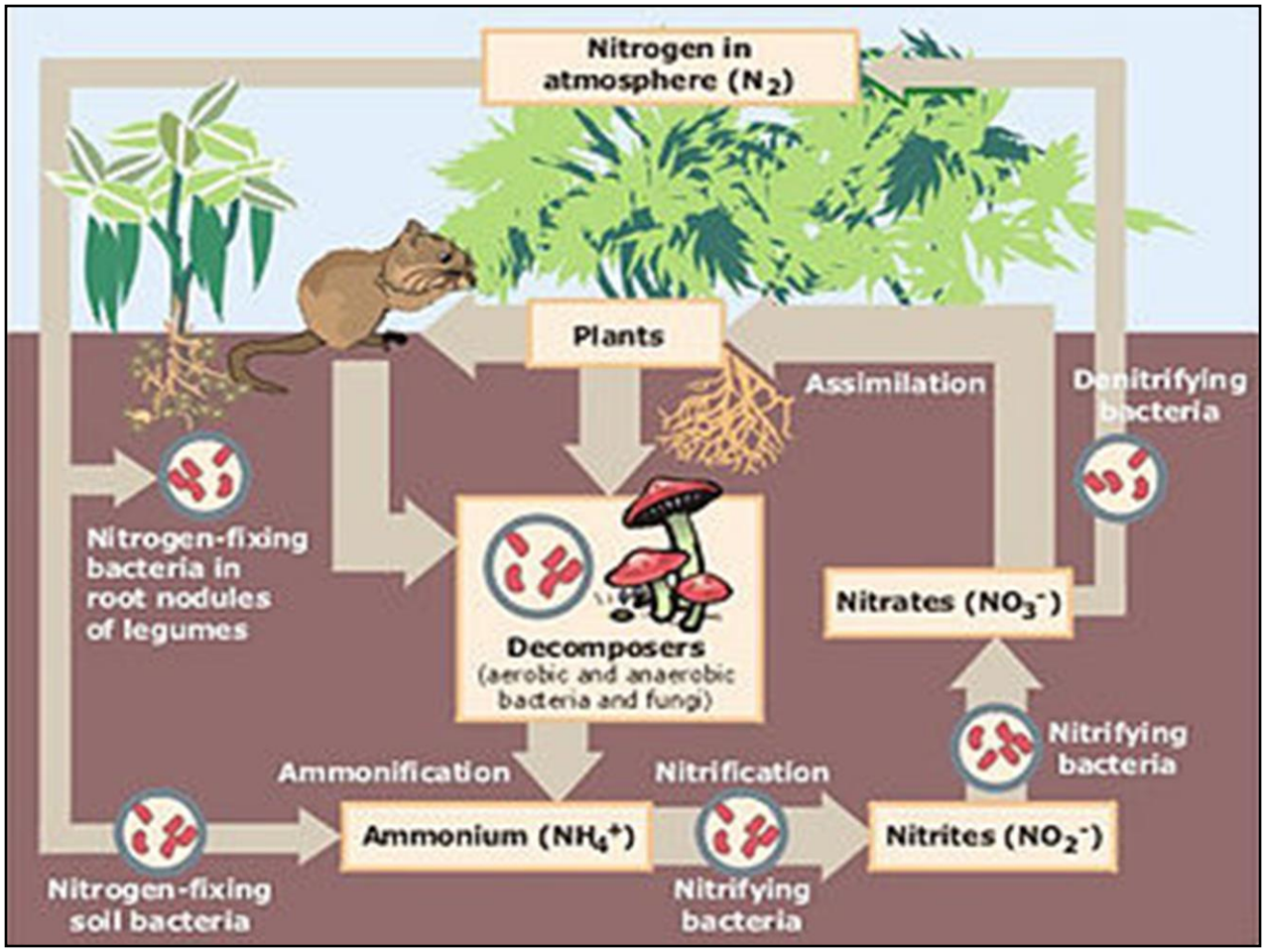
Carbon

Cycle mainly through **photosynthesis** & **Cellular Respiration**

CO_2

Organic Matter – Living (Biomass)

Organic Matter – Dead (Fossil Fuels)

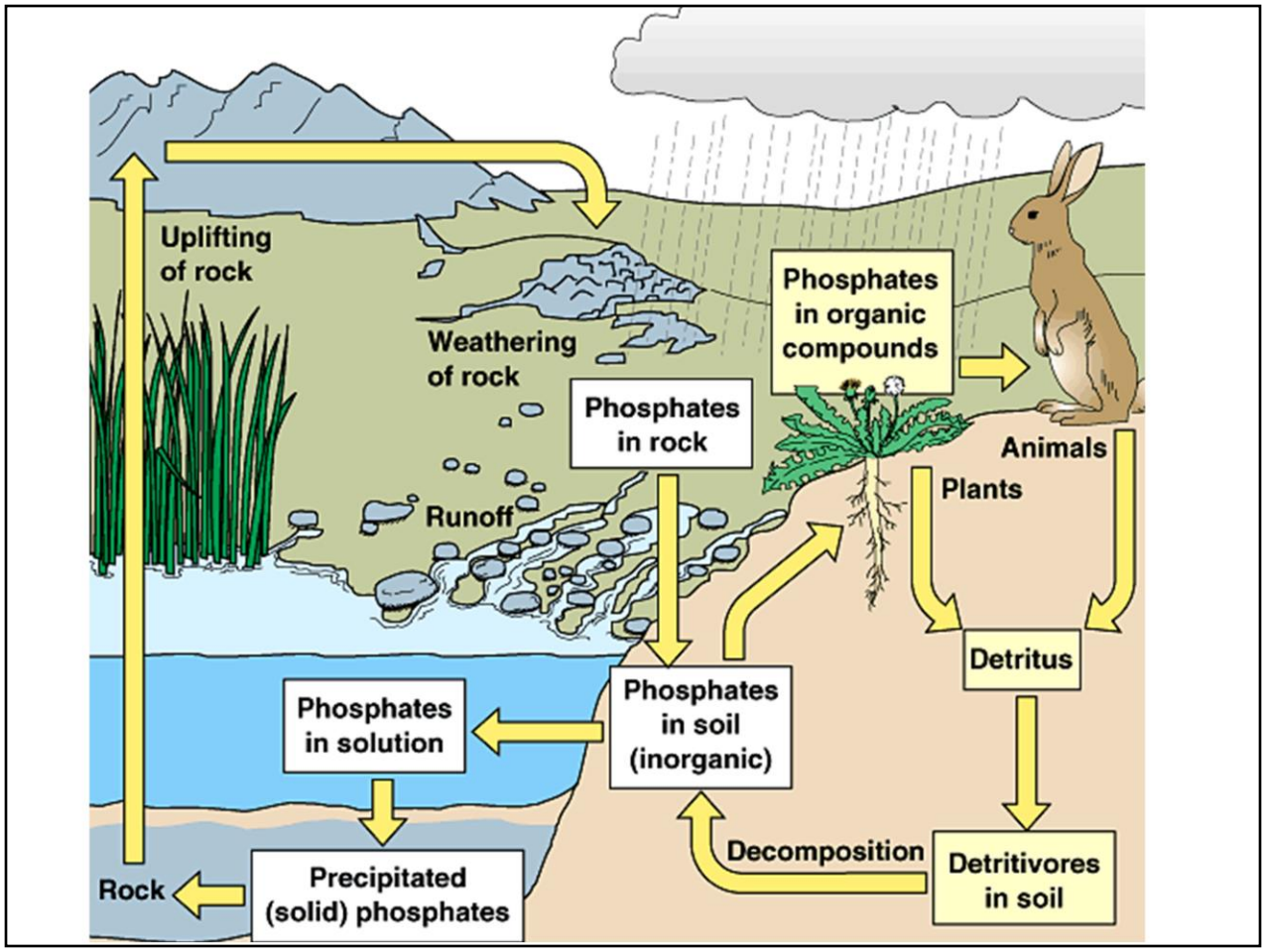


Nitrogen

Nitrogen w/ hydrogen = ammonia

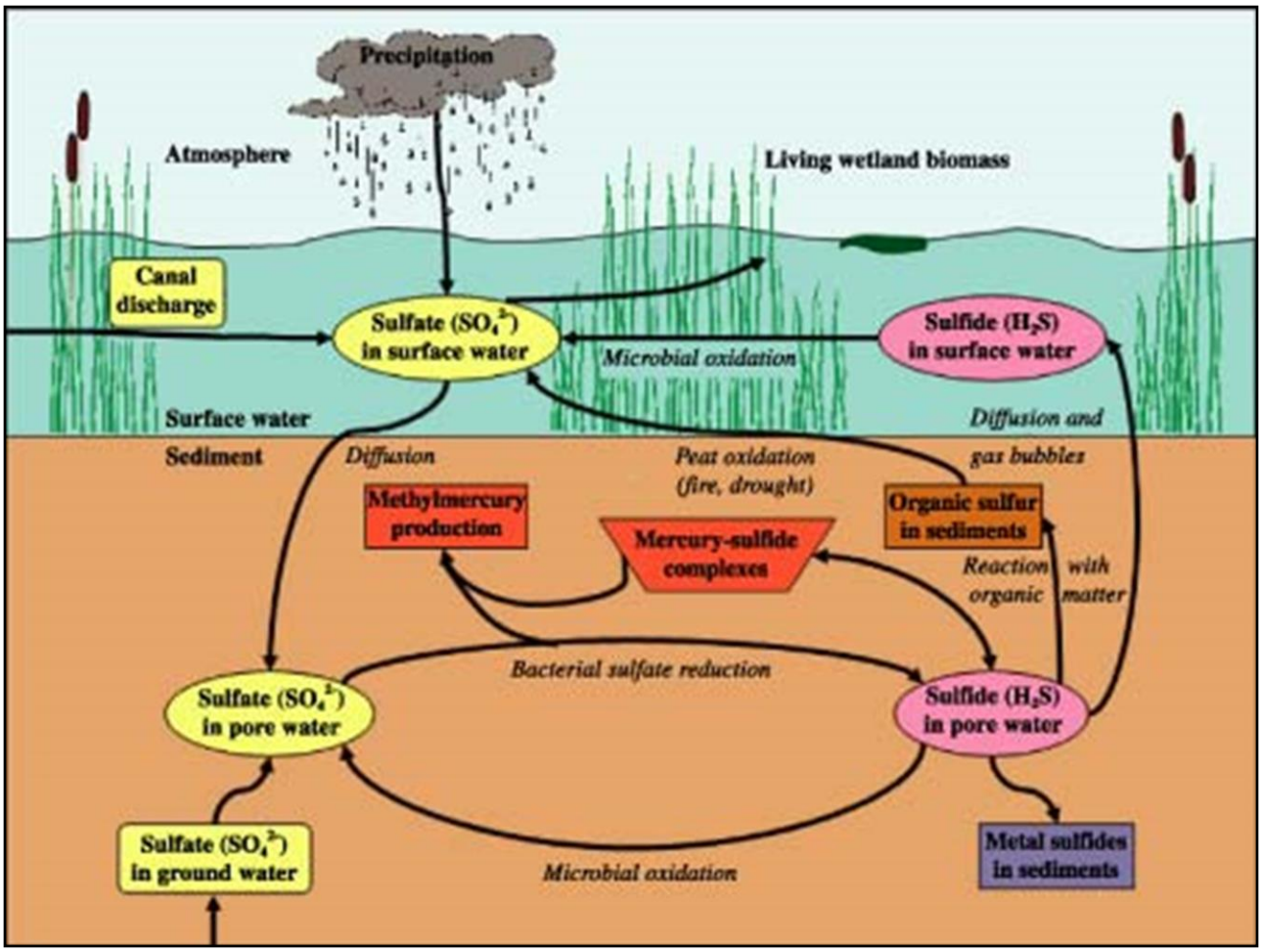
Moves from the environment to organisms; used in proteins & nucleic acids (DNA/RNA).

Bacteria are key to nitrogen recycling.



Phosphorous

Used in Nucleic Acids, Membrane Lipids, ATP, cAMP, & other molecules.



Sulfur

Used in Proteins - forms strong covalent bonds between amino acids.

3 samples of unknown biomolecules were extracted and the percentages of atoms were determined as shown below.

Sample	S	P	O	N	C	H
1	0	0	25	0	25	50
2	0	2	8	0	30	60
3	2	0	10	10	30	48

1. Sample 1 was most likely
    a. Nucleic Acid
    b. Lipid
    c. Carbohydrate

2. Sample 2 was most likely
    a. Lipid
    b. Carbohydrate
    c. Protein

3. Sample 3 was most likely
    a. Nucleic Acid
    b. Lipid
    c. Protein

4. A student claimed that one of the biomolecules was a Nucleic Acid. Explain why their claim is inaccurate.

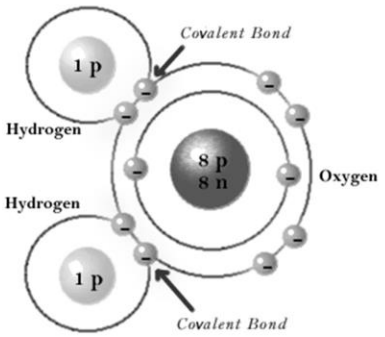
1. The main difference between saturated fats & unsaturated fats is the presence of double bonds in unsaturated fats. What is ultimately responsible for this variation?
    a. The low number of oxygen in fats allows them to take a variety of forms.
    b. The high number of hydrogens in unsaturated fats allows for more double bonds to form.
    c. The ability of carbon to form 4 bonds of different types allows for more variations in molecules.
    d. The double bonds in unsaturated fats are due to the variety of bond types that hydrogen can form.

2. Global warming is a dramatic effect of excessive burning of fossil fuels, releasing CO_2. The most rational explanation for why this form of CO2 release has sped up global warming is:
    a. Fossil fuel burning adds to the atmospheric CO2 quicker than photosynthesis consumes it.
    b. Fossil fuel burning adds to the atmospheric CO2 quicker than respiration consumes it.
    c. Fossil fuel burning adds to the atmospheric CO2 quicker than decomposition consumes it.
    d. Fossil fuel burning adds to the atmospheric CO2 slower than it diffuses into the ocean.
3. Animals have no mechanism to obtain nitrogen or phosphorous in an inorganic form. Which of the following best explains this?
    a. Any mechanism to obtain these resources must have been favorable during animal evolution.
    b. Animals didn't need these resources until recently in evolutionary history.
    c. Animals have no need for these mechanisms as they obtain them from consuming organisms with pre-existing forms of these resources.
    d. Plants have these mechanisms and animals obtain the resources from consuming the plants.

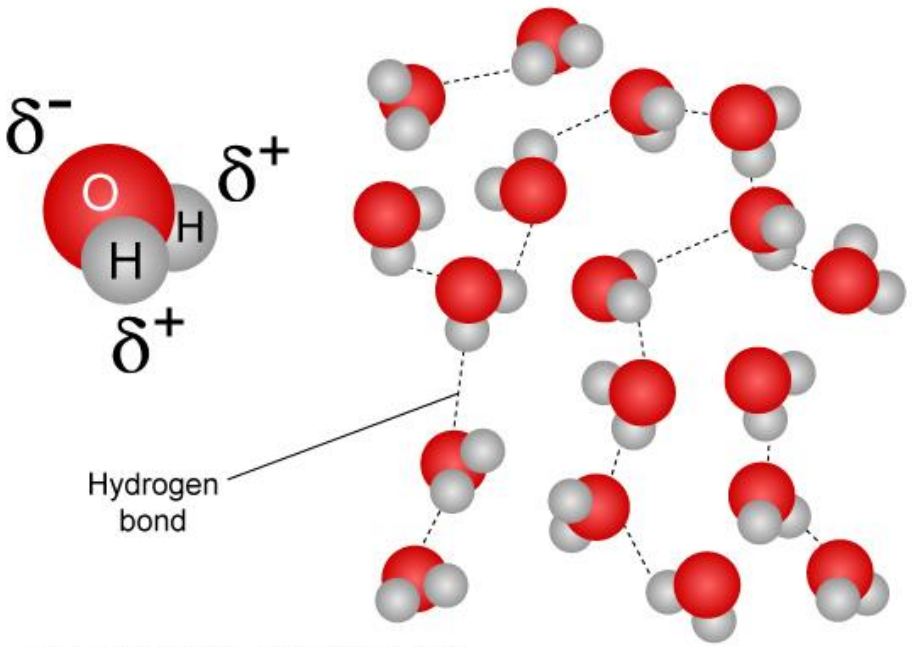
Molecular Structure of Water

- 1 Oxygen atom bound to 2 Hydrogen atoms
- Oxygen is electronegative – shifts electrons towards itself easily
- Results in 2 polar covalent bonds

- Water molecules become polar
  - *Partial* **negative** on oxygen
  - *Partial* **positive** on hydrogens



Hydrogen bonds are weak bonds between hydrogens and negative regions on other atoms.



(length appears different for perspective (3D))

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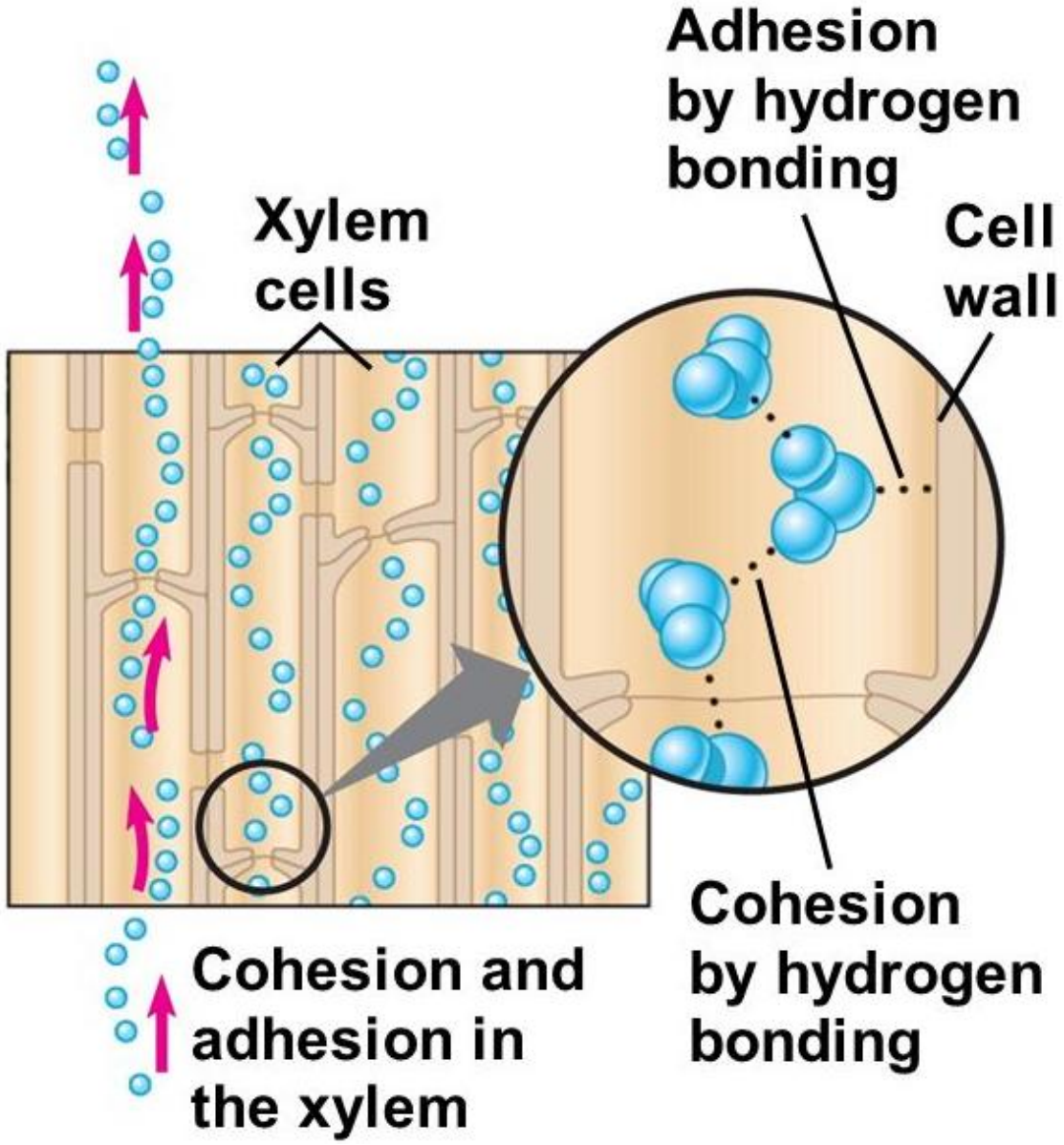
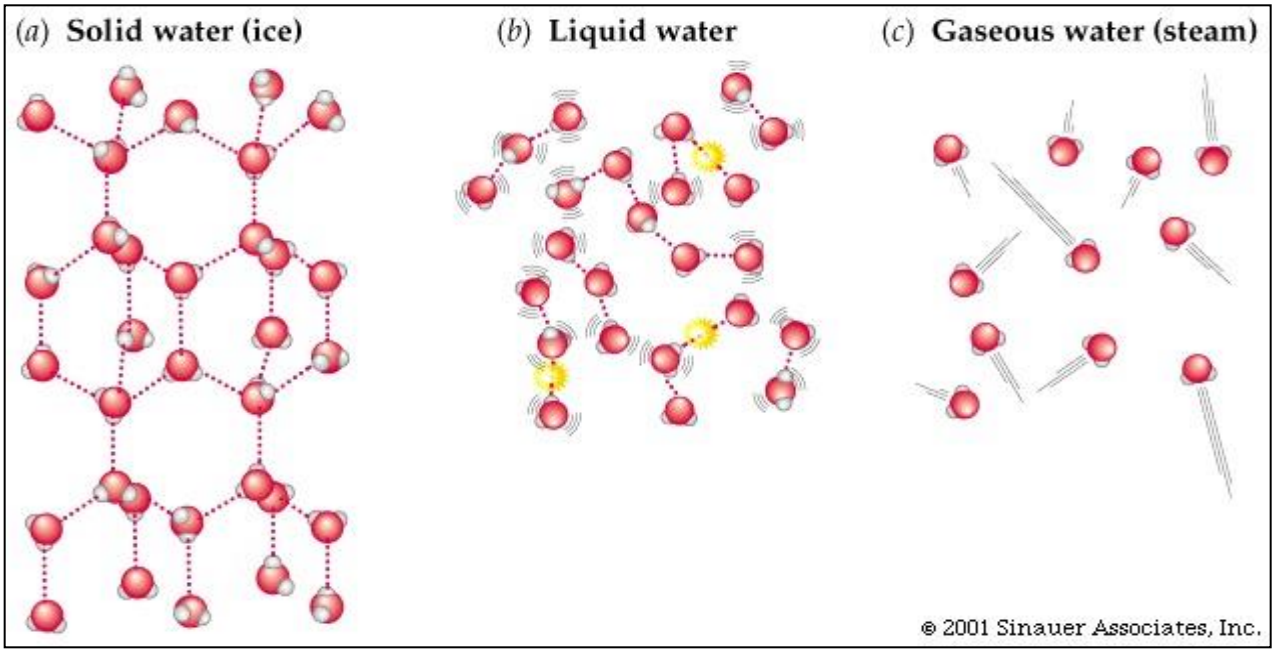
Water's Properties

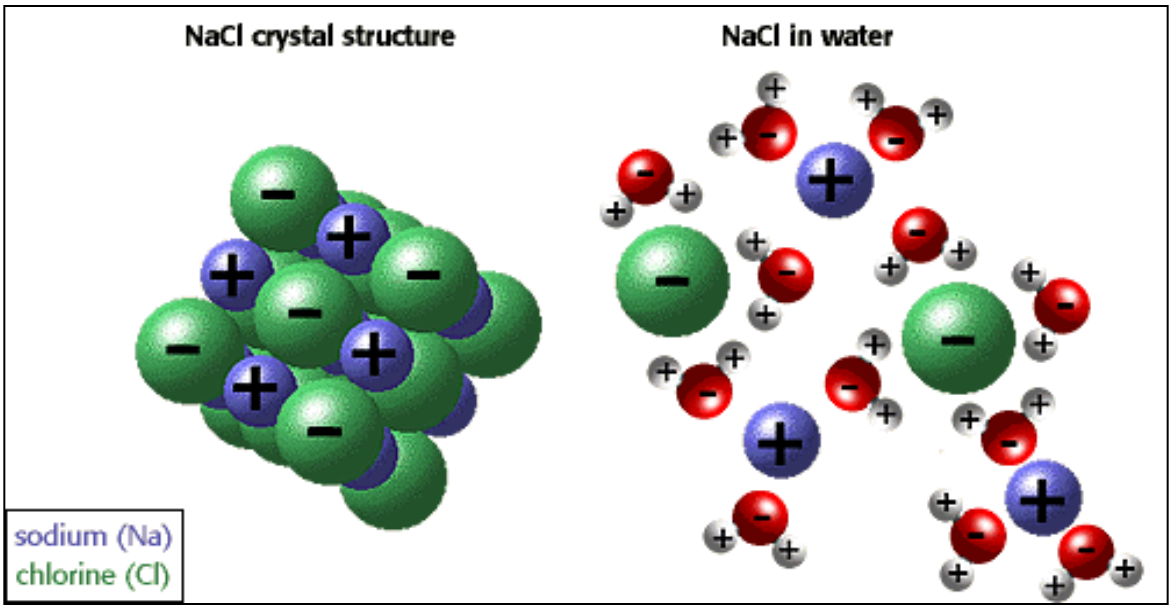
- As a result of hydrogen bonding, water…
  1. Has a **high specific heat**
     a. Difficult to change from one phase to another
     b. Allows for a large quantity of heat to be absorbed/released before "boiling" or "freezing"
  2. Is able to **strongly bind** to
     a. Itself – **Cohesion**
     b. Other polar/charged molecules – **Adhesion**



Water's Properties

- As a result of hydrogen bonding, water…
  3. Is **less dense as a solid** than a liquid
     a. Hydrogen bonds hold solid crystal-like structure as a solid
  4. Is able to **dissolve** *almost* any compound
     a. Biological **Solvent** supporting reactions





As water flows into plant roots, it carries dissolved minerals & nutrients. As the sun increases the external temperature, water is drawn up through the plant body in narrow tubular cells called xylem. This process as a whole is known as transpiration. Which property of water is least helpful for understanding the process of transpiration in plants?

a. Cohesion & Adhesion
b. High Specific Heat
c. Higher Density as a Liquid than a Solid
d. Biological Solvent

Water Potential

- Because water is polar, it tends to move towards solutes.
- Water moves from areas of high water potential (low solute concentration) to areas of low water potential (high solute concentration)
- This is the rationale behind Osmosis

Water potential (Ψ) = pressure potential (Ψ_P) + solute potential (Ψ_s)

Water potential is determined by 2 things:

1. The solute potential – The effect of solutes

$\Psi_s = -iCRT$

i = ionization constant (number of particles that the molecule breaks into)

(sucrose/glucose = 1 since it does not ionize in water)

(NaCl = 2 since it ionizes into 2 ions in water)

C = molar concentration of solution (expressed as ___**M**)

R = pressure constant (0.0831)

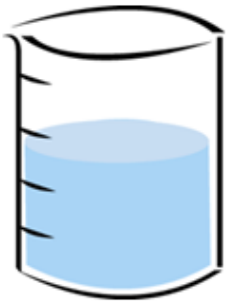
T = Temperature in KELVIN (273 + celcius temperature)

2. The pressure potential Ψ_P

Pressure potential in an animal cell or an open container is 0 because nothing will exert pressure back as water moves.

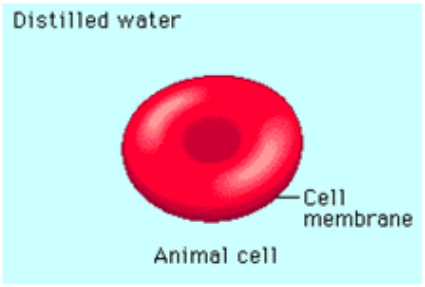
Other cells have **cell walls** that will **increase** pressure as water moves into their cells.

Pure water



0.2M red blood cell

(assume i = 3, 20°C)



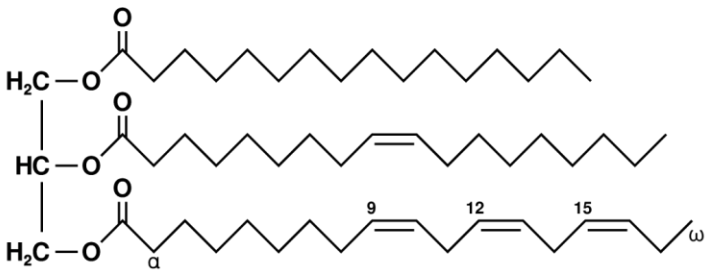
Calculate the water potential, solute potential and pressure potential for each. (Round to nearest whole number).

Water always moves from areas of higher water potential (higher values) to areas of lower water potential (lower values). Use this rule and your calculations to explain why the red blood cell bursts open when placed in pure water.

A potato (assume 0.2M sucrose) is placed into a 0.8M sucrose solution at 20°C. Predict what would happen to the potato and **justify** your predictions using you calculations.

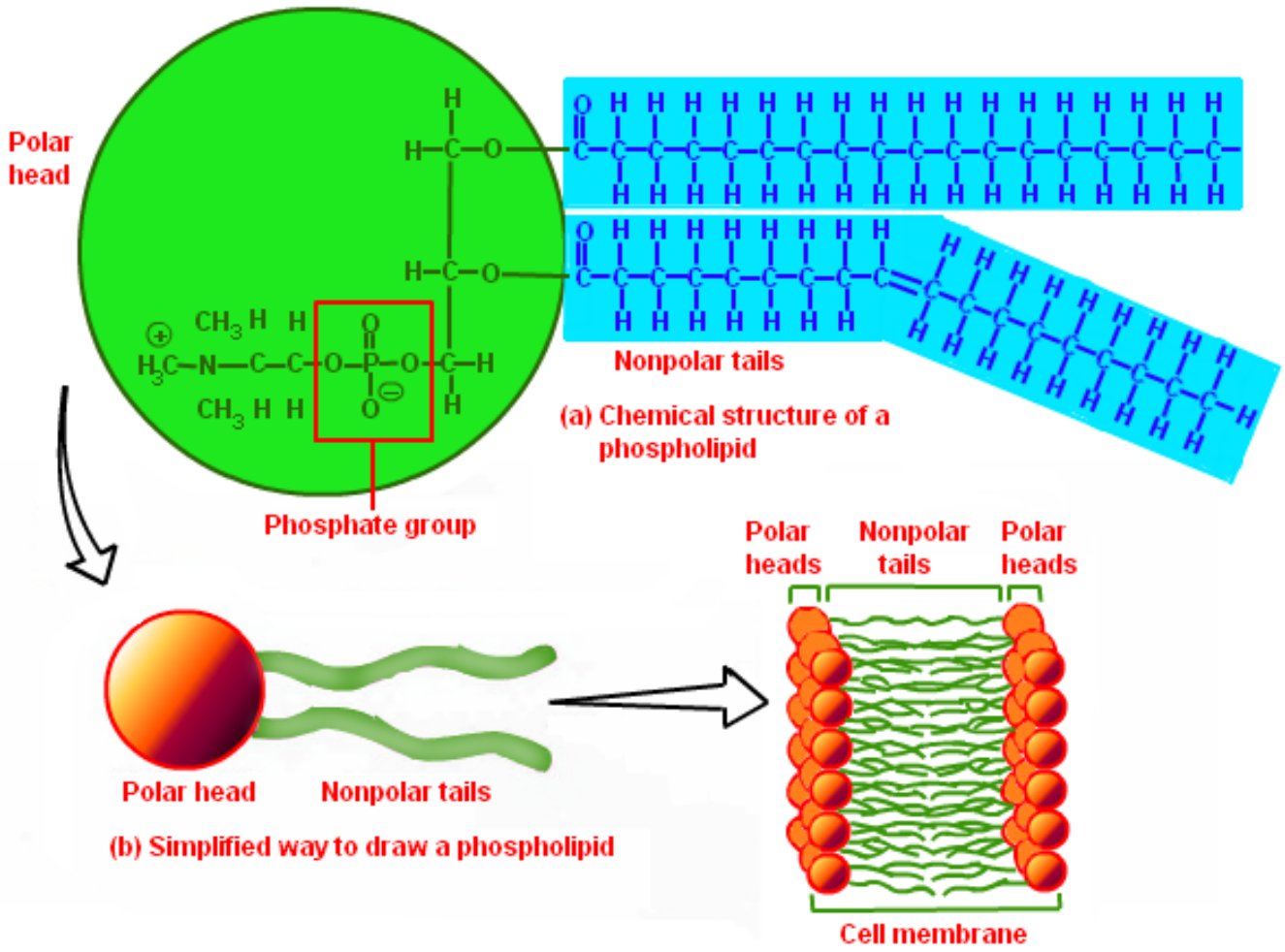
Cell Origins

- Cells could not have evolved if everything could dissolve in water.
- **Lipids** are insoluble in water meaning they maintain their structure.
- Hydrocarbons are non-polar
  - No/few electronegative atoms to attract water
  - In fact, they repel water = Hydrophobic
- But cells need to contain all types of molecules, hydrophilic & hydrophobic.



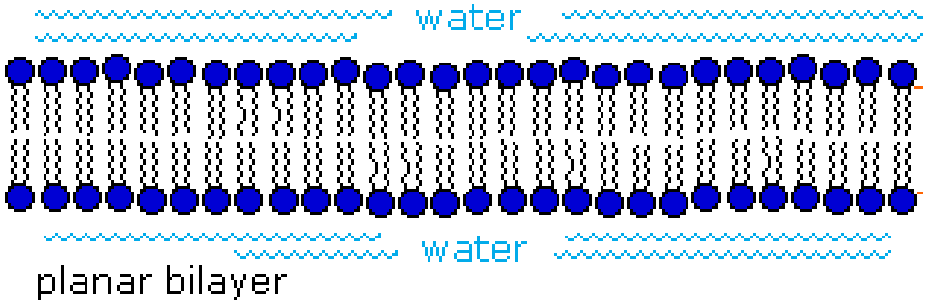
Phospholipids

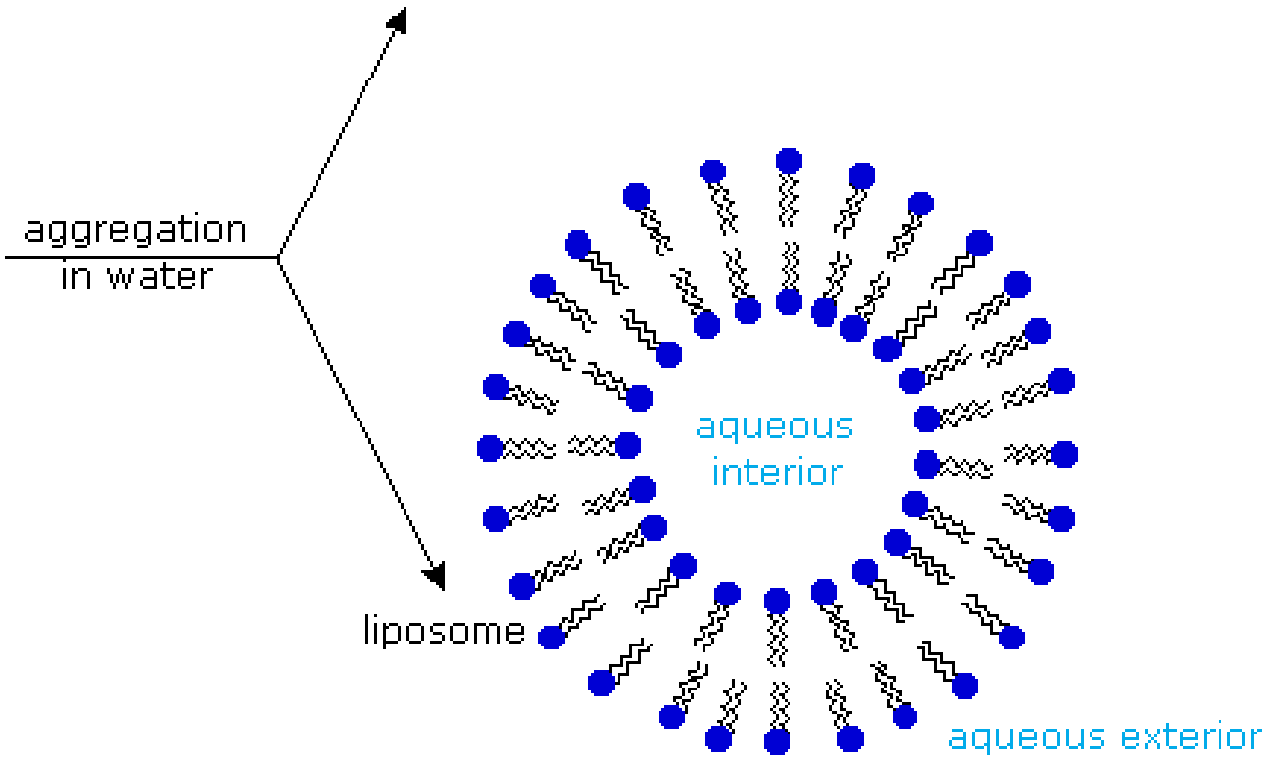
- Phospholipids were the solution.
- A **polar end** and a **non-polar end** <u>combined</u> in a single molecule.
- When many phospholipids combine, their polar ends face aqueous environments & their non-polar ends face each other to repel water.



Membrane Structure

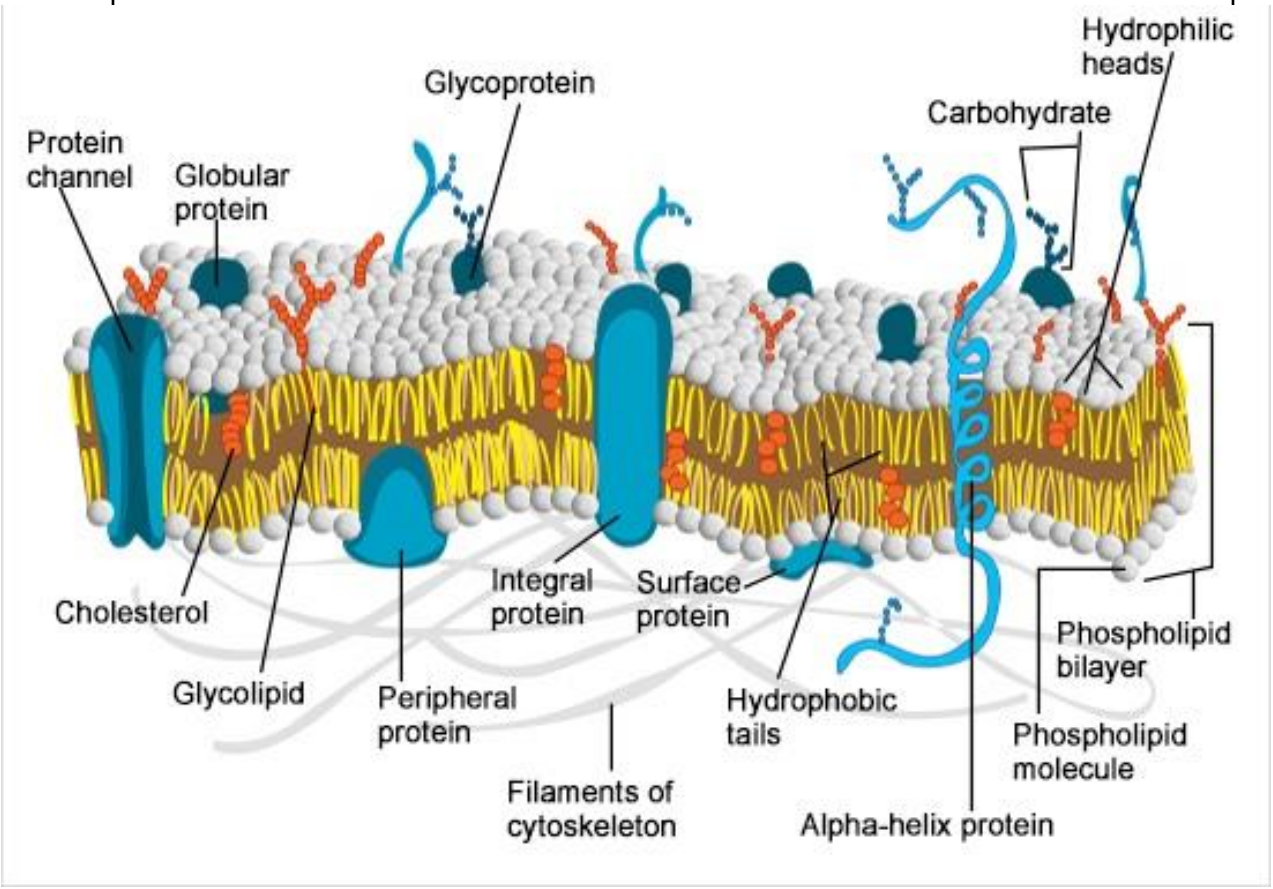
- 2 Layers of **Phospholipids**
  - **Lipid Bilayer**
- Maintains a specific environment inside of the cell



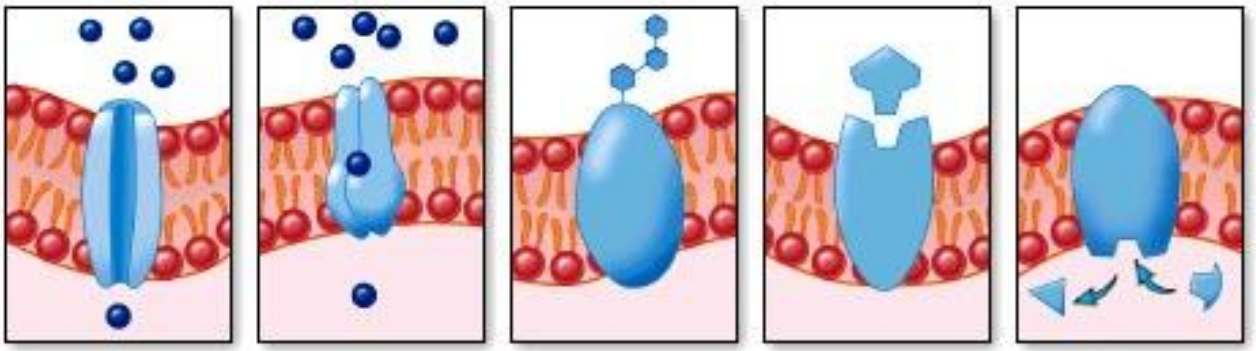


Membrane Structure

- Membranes also have a variety of molecules embedded within or at their surface.
- Called the "Fluid-Mosaic Model"
  - Fluid = The Bilayer of Phospholipids
  - Mosaic = The molecules integrated into the bilayer

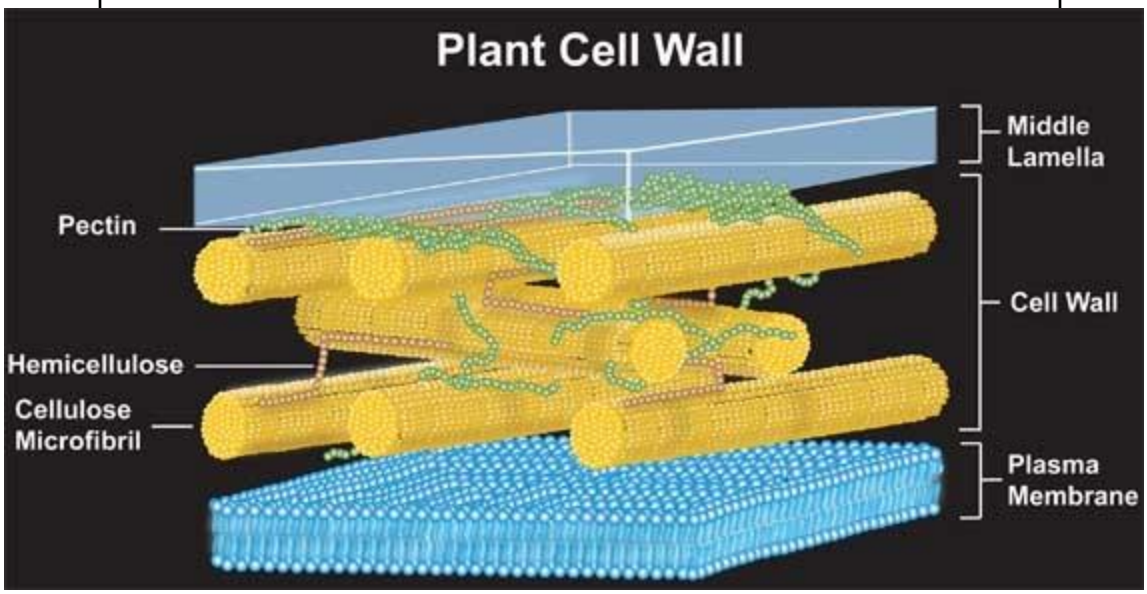


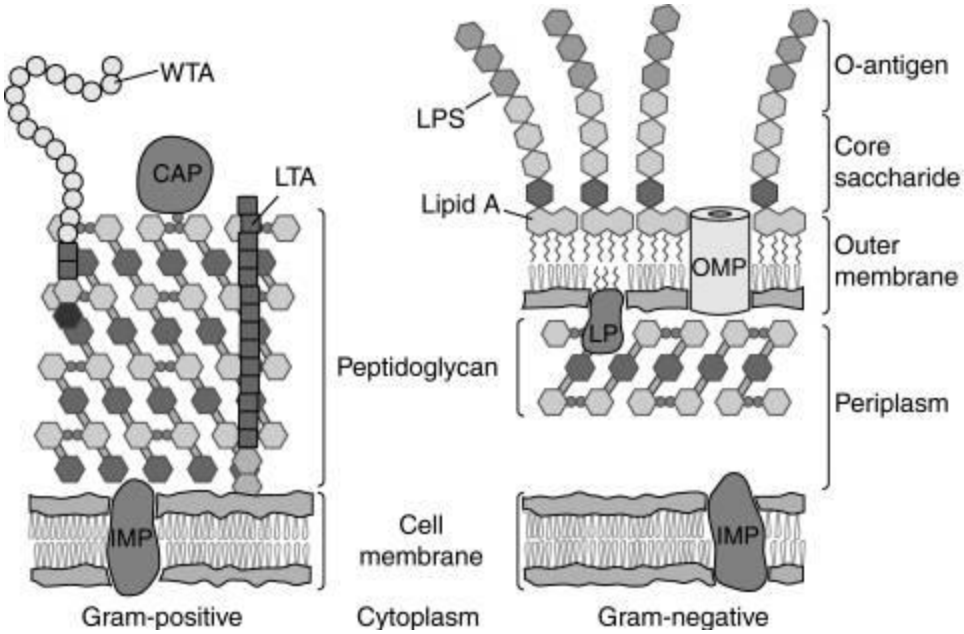
Integral Proteins & Their Functions



Cell Walls

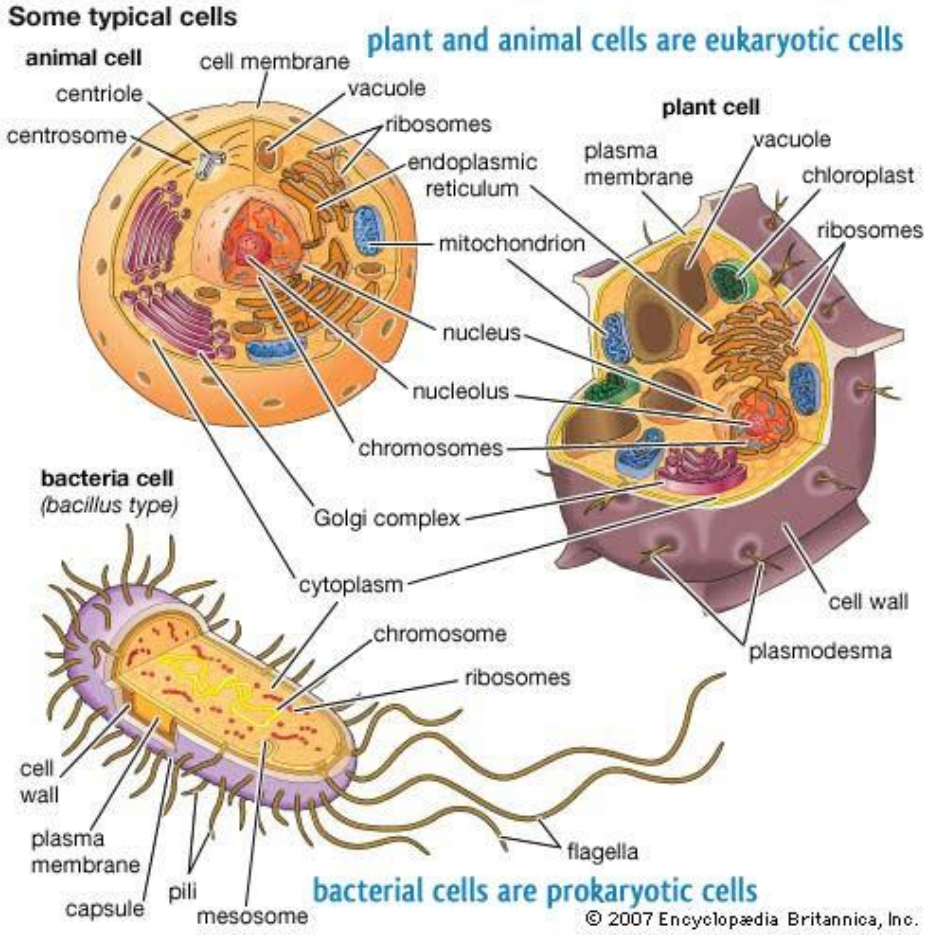
- Plants have cell walls external to the membrane. Made of carbohydrates called cellulose & pectin.
- Prokaryotes, Fungi & many protozoa have cell walls too.
- All serve as structural boundaries and permeability barriers for some substances.





Eukaryotes vs. Prokaryotes

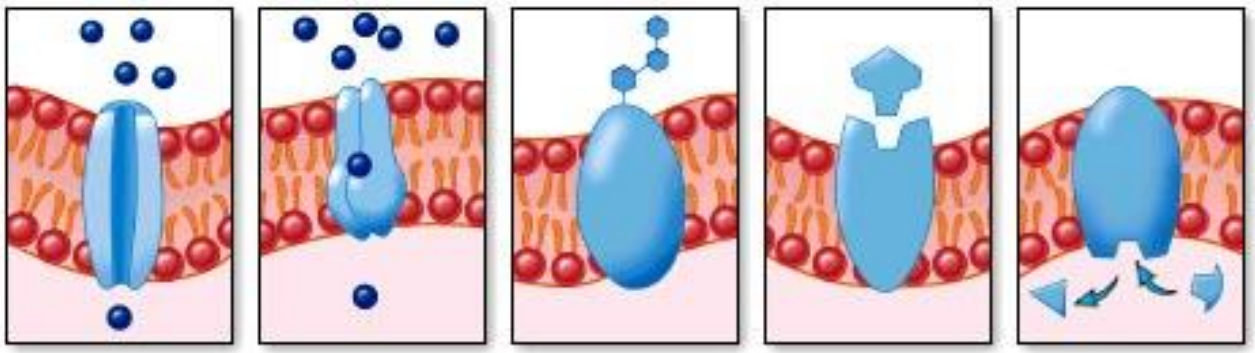
- ***Internal*** membranes facilitate cell processes by minimizing competing interactions and by increasing surface area where reactions can occur
- Prokaryotes LACK these internal membranes, meaning no organelles!
- Organelles compartmentalize internal processes and specific enzymatic reactions.



1. Which of the following was an important advancement of eukaryotes?
    a. The ability to develop specialized cells was possible due to compartmentalization of specific cell tasks.
    b. The ability to store genetic information made evolution occur faster.
    c. The development of cell walls provided better protection.
    d. The ability to form a phospholipid bilayer made cell specialization possible.

2. The production of membrane proteins is much faster in eukaryotes than in prokaryotes. The most likely reason for this is
    a. Prokaryotes don't need the large number of proteins as eukaryotes.
    b. Prokaryote cell membranes are much smaller than those of eukaryotes.
    c. These protein-producing reactions are in competition with other reactions in prokaryote cells.
    d. These proteins are larger and thus require more time to manufacture.

3. In multicellular organisms, cells must be able to determine which cells are theirs and which are foreign and thus potentially harmful. Which of the following integral protein(s) would best serve this function?



A B C D E

4. Soaps are similar in nature to phospholipids in that they have polar & non-polar regions. When soap is used, most of the debris (dirt, bacteria and viruses) are dissolved in the soap. Which description best explains this mechanism?
    a. The polar regions of soap attract the hydrophobic regions of the debris away from the skin.
    b. The non-polar regions of soap attract the hydrophilic regions of the debris away from the skin.
    c. The polar regions of soap attract the hydrocarbon regions of the debris away from the skin.
    d. The non-polar regions of soap attract the hydrophobic regions of the debris away from the skin.

5. Atherosclerosis is caused by a buildup of cholesterol in the arteries. The most likely reason for this is
    a. Cholesterol is hydrophilic and will want to stay attached to the membrane of the artery.
    b. Cholesterol is hydrophobic and will want to stay attached to the membrane of the artery.
    c. Cholesterol is hydrophilic and will want to remain flowing with the aqueous blood.
    d. Cholesterol is hydrophobic and will want to remain flowing with the aqueous blood.

Exchanges with Environment

- Cells are the basic unit of exchange, even in large multicellular organisms.
- Why not be just 1 enormous cell???
- Issue of surface area – volume ratios
- As cells increase in size, the volume increases faster than the membrane's surface area.
- More demand for exchange, not enough area to make the exchanges!

SA to Volume Ratios

V = L x W x H

SA = H x W x # of sides

SA / V = Ratio

Smaller cells more favorable!

Transport Across Cells

- Materials must move in and out of cells to maintain homeostasis.
- Molecule movement depends on 3 things
  - Size of molecules
  - Charge of the molecules
  - Direction of movement (gradient)
    - Down = from high concentration to low concentration
      - Passive Transport requires **no energy**
    - Against =from low concentration to high concentration
      - Active Transport **requires energy** (ATP/Electron Carriers)

Particle Size	Charge	Gradient	Transport Type	Examples
Small	Uncharged	Down	Passive – Simple Diffusion	CO_2, O_2, H_2O
Small	Charged	Down	Passive – Facilitated Diffusion (Transport Proteins)	K+, Na+, Ca+,
Small	Polar	Down	Passive - Osmosis (Aquaporins)	H_2O
Small	Charged	Against	Active - Ion Pumps	H+, K+, Na+
Medium	Irrelevant	Against	Active - Cotransport	Glucose, Sucrose, Amino Acids
Large	Irrelevant	Irrelevant	Active - Exocytosis & Endocytosis	Polymers, Pathogens

Use these pages to take notes on the mini-lessons given by students on their transport type examples…don't forget yours also!

Unit 2

Part 3

Uses of Energy for Regulation

AP Biology

Mrs. Petrov

Disruptions

- All biological ***systems*** are affected by disruptions.
  - Organism dehydration
  - Immune responses to pathogens
  - Invasive species
  - Hurricanes, Floods, Volcanoes

Types of Homeostatic Responses that can Counteract Disturbances

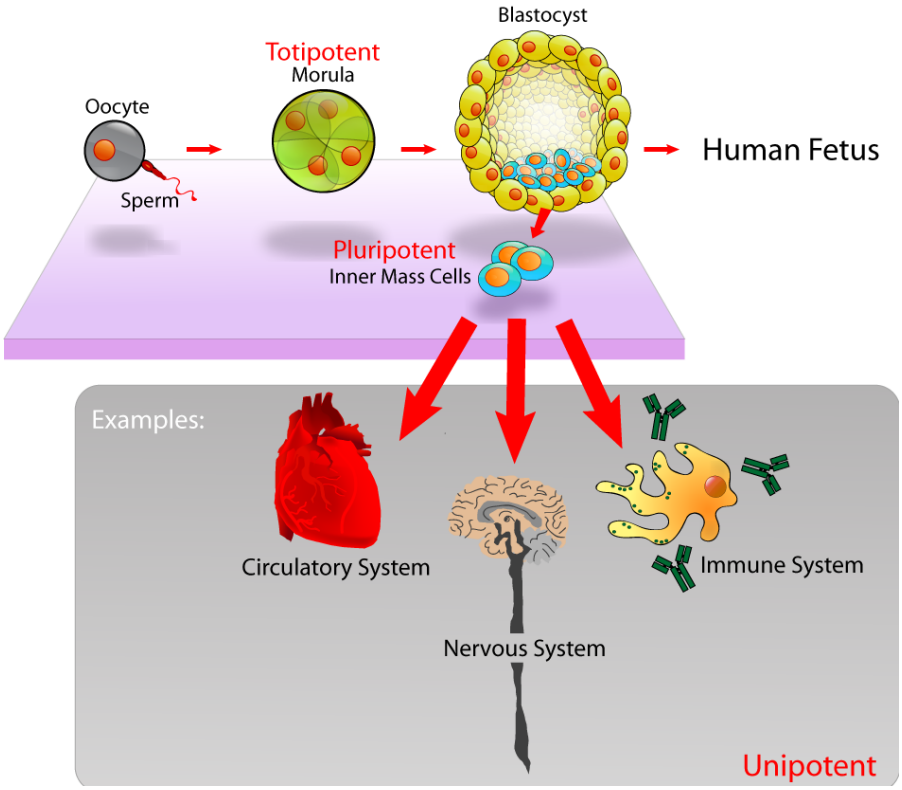
Behavioral

- Nocturnal activity
- Hibernation
- Change in Location

Physiological

- Immune responses
- Shivering
- Sweating
- Phototropism

It all Starts with Organism Development

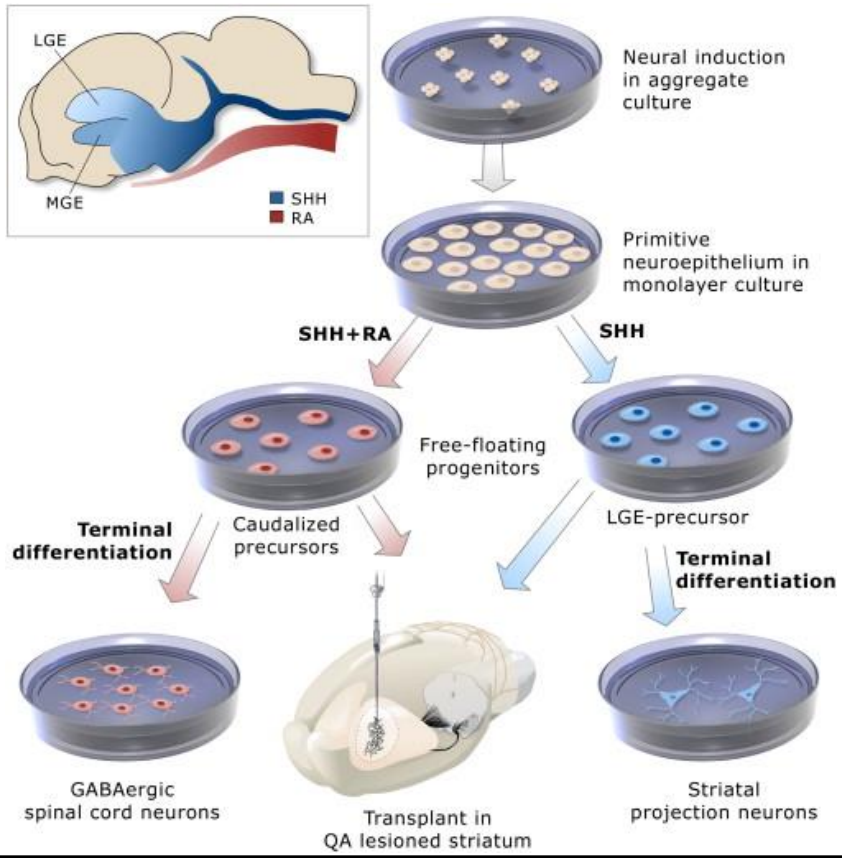


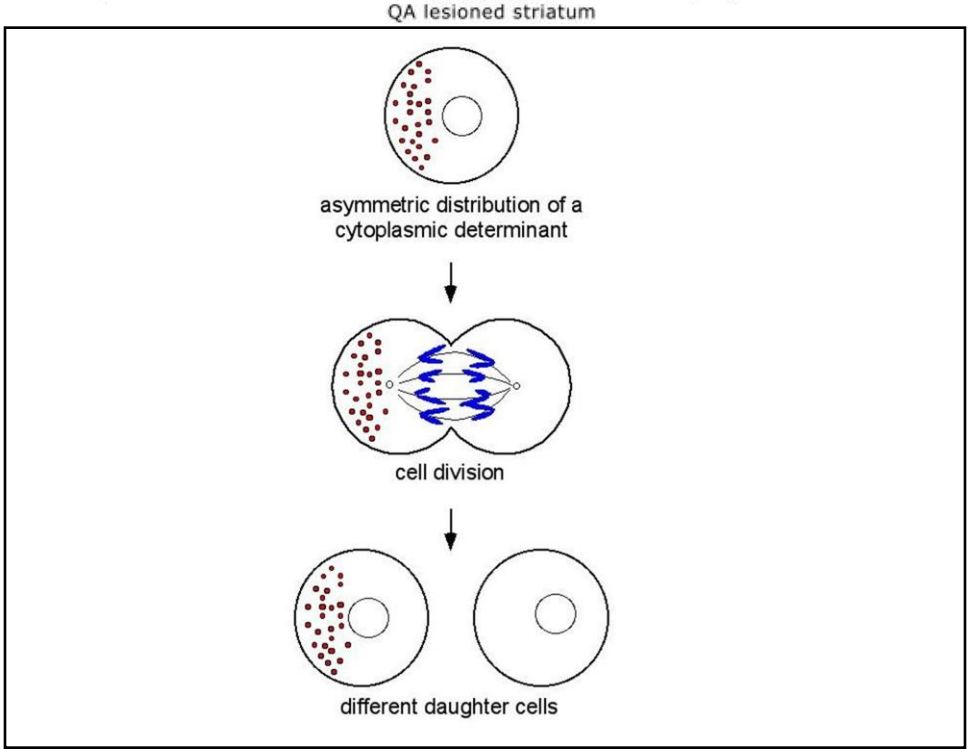
- ALL cells (except immune) have a complete set of instructions (DNA).
- Why do they end up looking ***different***???
  - Blood cells Nerve cells Skin cells

- The DNA is ***expressed differentially!***

- Regulators are proteins inherited from the mother/parent cell

  Transcription Factors Inductive signals





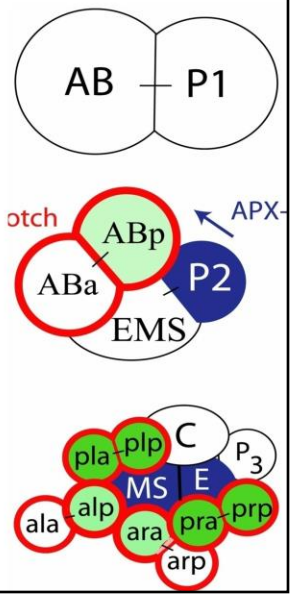
Cytoplasmic determinants & concentration gradients

More/less of a transcription factor will cause DNA to be expressed more/less

What is the result of this?

Induction & Coordination of Events

- P_1 division asymmetric; produces EMS and P_2 that express distinct sets of proteins.
- AB division symmetric; Produces ABa and ABp; initially equivalent.
- However, the posterior displacement of ABp puts it in contact with the P_2 cell; thus some genes are activated in ABp, but ***not*** in ABa.
- Likewise, some genes expressed in ABa due to contact with EMS.



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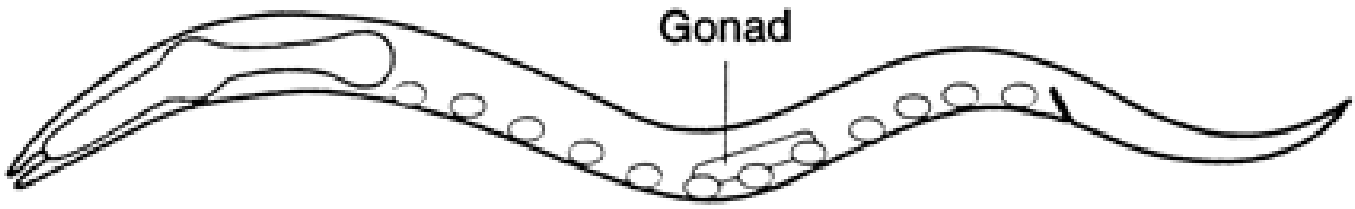

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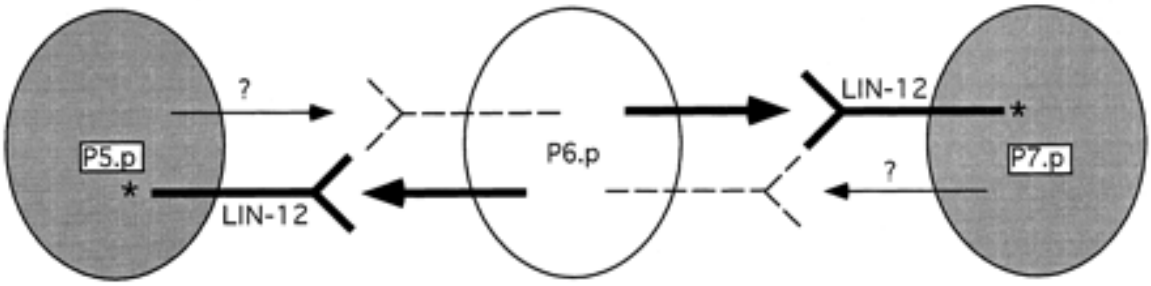


miRNA

- MicroRNAs extremely important during development.
- Embryonic stem cells that do not form miRNAs fail to differentiate in vitro and in vivo.
- Regulate gene expression by either **degrading** mRNAs or **blocking** their translation.

Why would **degrading/blocking** protein production be important during development?

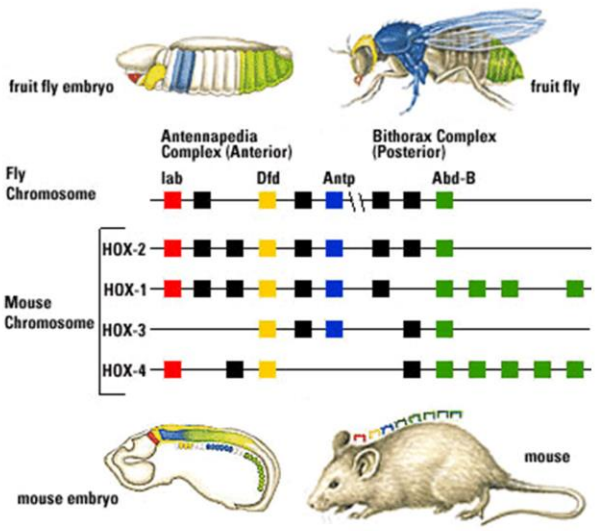
Apoptosis: Programmed cell death

•Normal development of the fingers and toes depends on death of the cells forming webs between them.

•In carnations, ethylene produced from the pollinated stigma is translocated, via the style and ovary, to the petals. Here it up-regulates ethylene biosynthetic genes and induces the production of ethylene in the petals. This ultimately leads to death of the flowers.

Homeotic (HOX) Genes

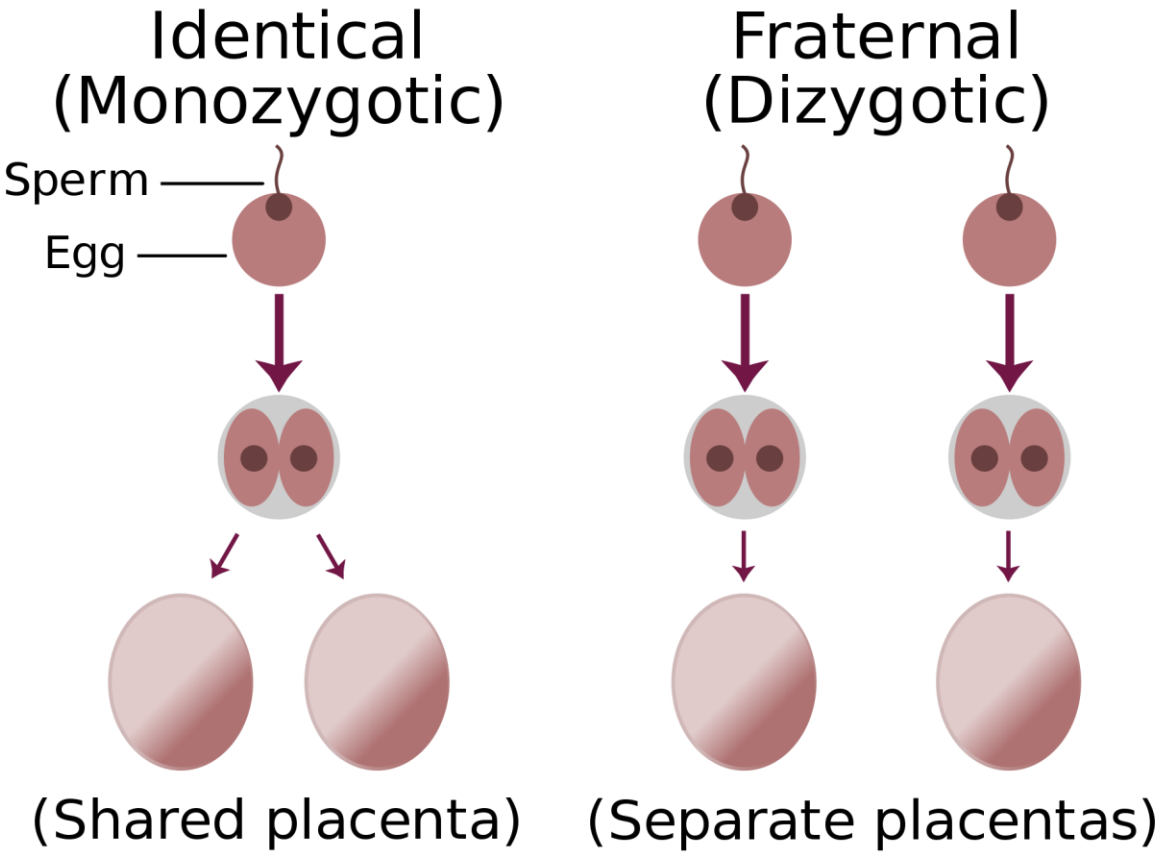
- Developmental Patterns & Sequences
- Body Plan
- Small mutations are **LETHAL**
- Common to most animals.



How is the theory of evolution/common descent supported by this data?

Use the following information to answer questions 1-3 on the following page.

Fraternal twins result when 2 distinct egg cells are fertilized by 2 distinct sperm cells but both fertilized eggs then develop independently. Identical twins result when a single egg is fertilized by a single sperm, the fertilized egg then divides but the division results in the 2 cells separating instead of staying attached as in a usual single-zygote development pathway. The diagram below shows the cell divisions



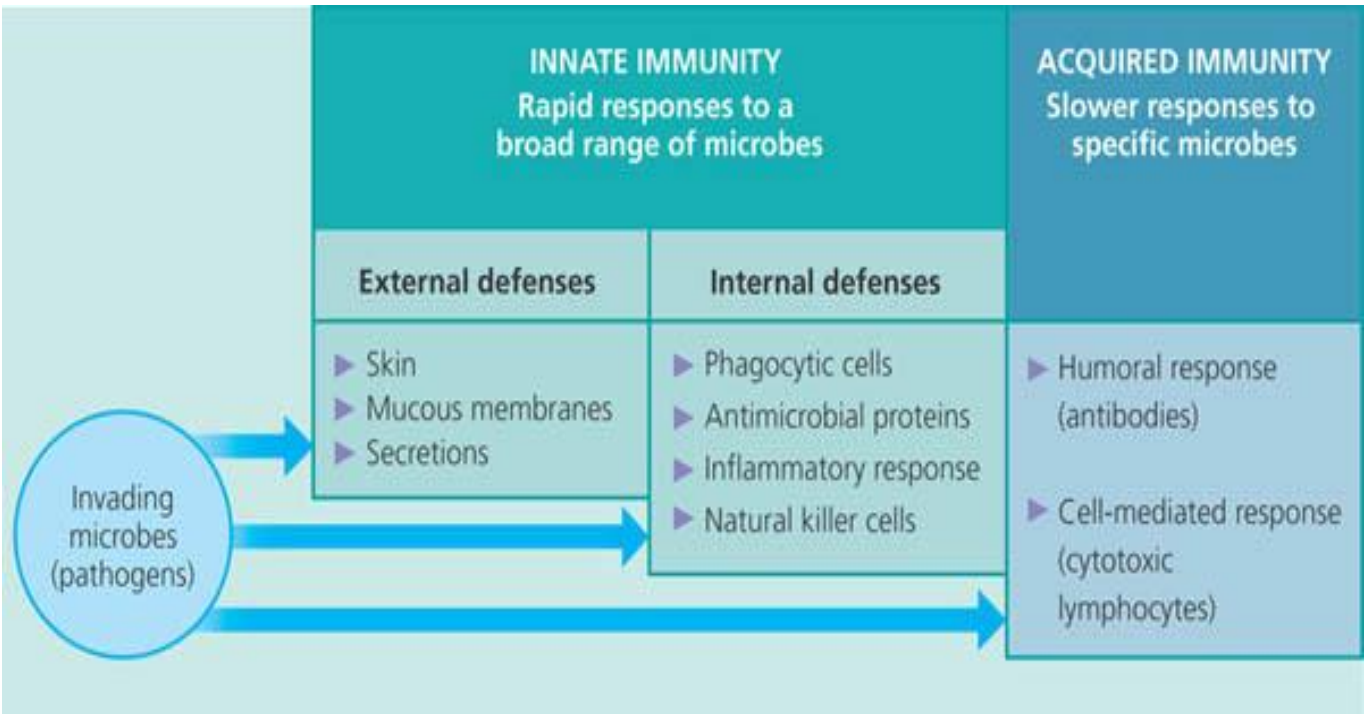
1. In identical twins, which of the following could cause them to be different?
    a. The same transcription factors being present in the same initial concentrations in both zygotes.
    b. The 2 zygotes developing in close proximity to one another.
    c. One zygote being male & the other female.
    d. Materials moving into the zygotes from the placenta at different rates.

2. In the fraternal twins, which of the following factors would least likely contribute to their differences in early development?
    a. Their DNA
    b. Their types and concentrations of transcription factors
    c. Their types & concentrations of miRNA
    d. Their cell size

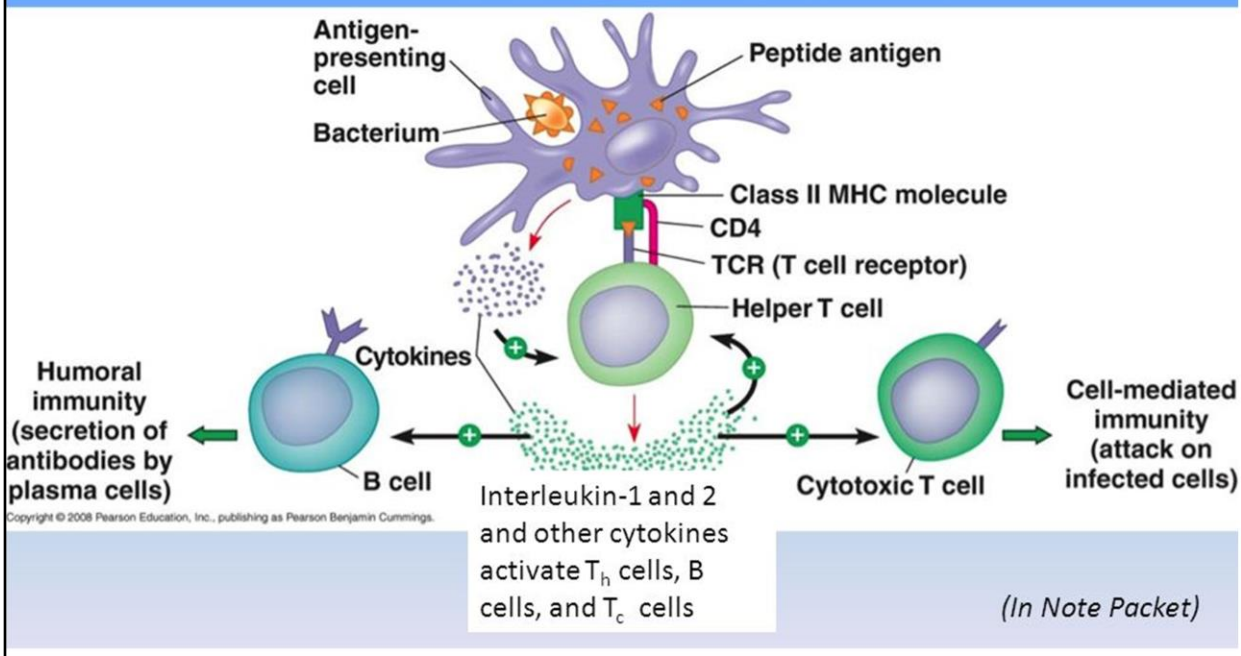
3. As zygotes develop, their cells divide & thus DNA replicates. DNA replication incurs mutations randomly, but studies have shown these mutations do not directly cause phenotype changes among twins. A researcher studying identical twins noticed a difference in multiple phenotypes among the identical twins at birth. Which of the following questions would best answer their question about the role of DNA mutations on differences in identical twin phenotypes?
    a. Did the mother have a proper diet during her pregnancy?
    b. Were both zygotes exposed to the same amounts of radiation?
    c. Were the mutations on genes coding for miRNA?
    d. Were HOX genes the sites of these mutations?

Defenses Against Pathogenic Disruptions

- Plants & Animals have a variety of chemical defenses against infections that would otherwise affect homeostasis
- Plants, invertebrates & vertebrates have many non-specific immune responses
- Vertebrates also use specific immune responses



Central Role of Helper T-cells



(In Note Packet)

Acquired Immunity – Immune Responses that mount responses to specific pathogens, also called Specific Immune Responses & Adaptive Immunity

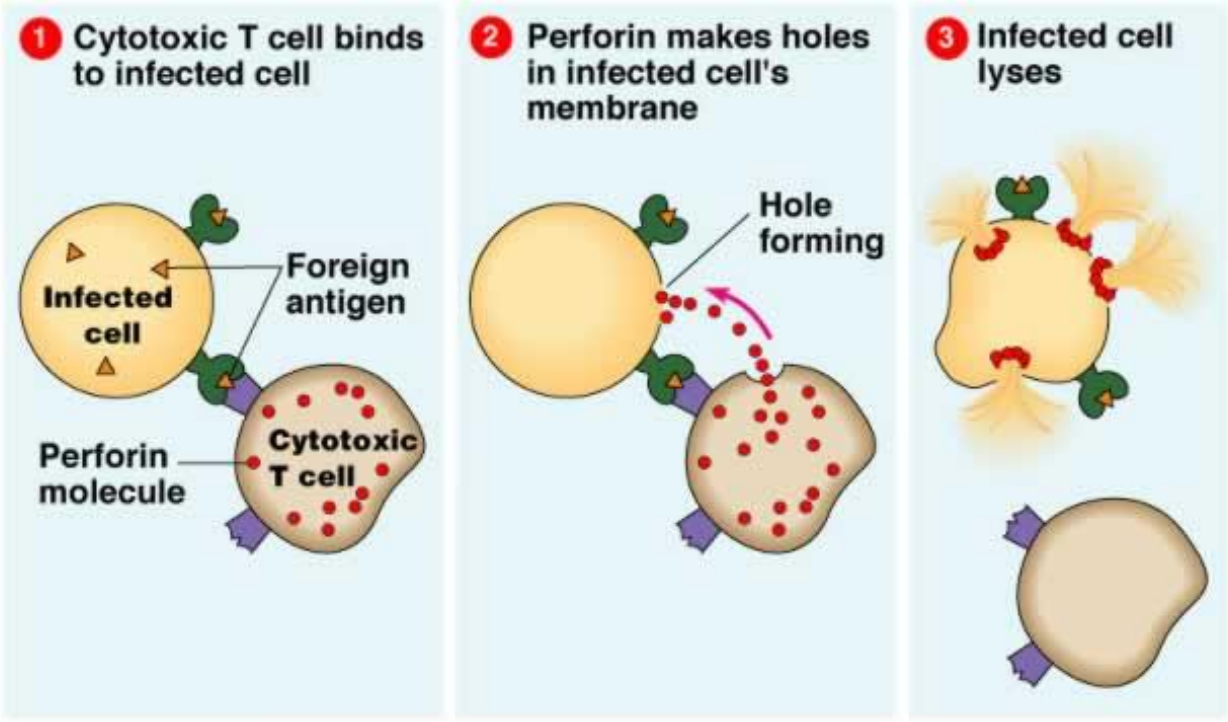
Helper T-cells are crucial in this type of immunity since **they activate** both cell types in their respective attack strategies

Cytotoxic T Cells are activated to target & destroy infected cells based on what the Helper T cell presented to them. Memory cells are also produced that will allow the same pathogen to be targeted quickly the next time.

B-Cells are activated to target & attach to specific pathogens roaming free in the body, based on what the Helper T cell presented to them. Antibodies are produced that attach to the pathogens and make them targets for other Killer cells. Antibodies remain & memory cells also produced that will allow the same pathogen to be targeted quickly the next time.

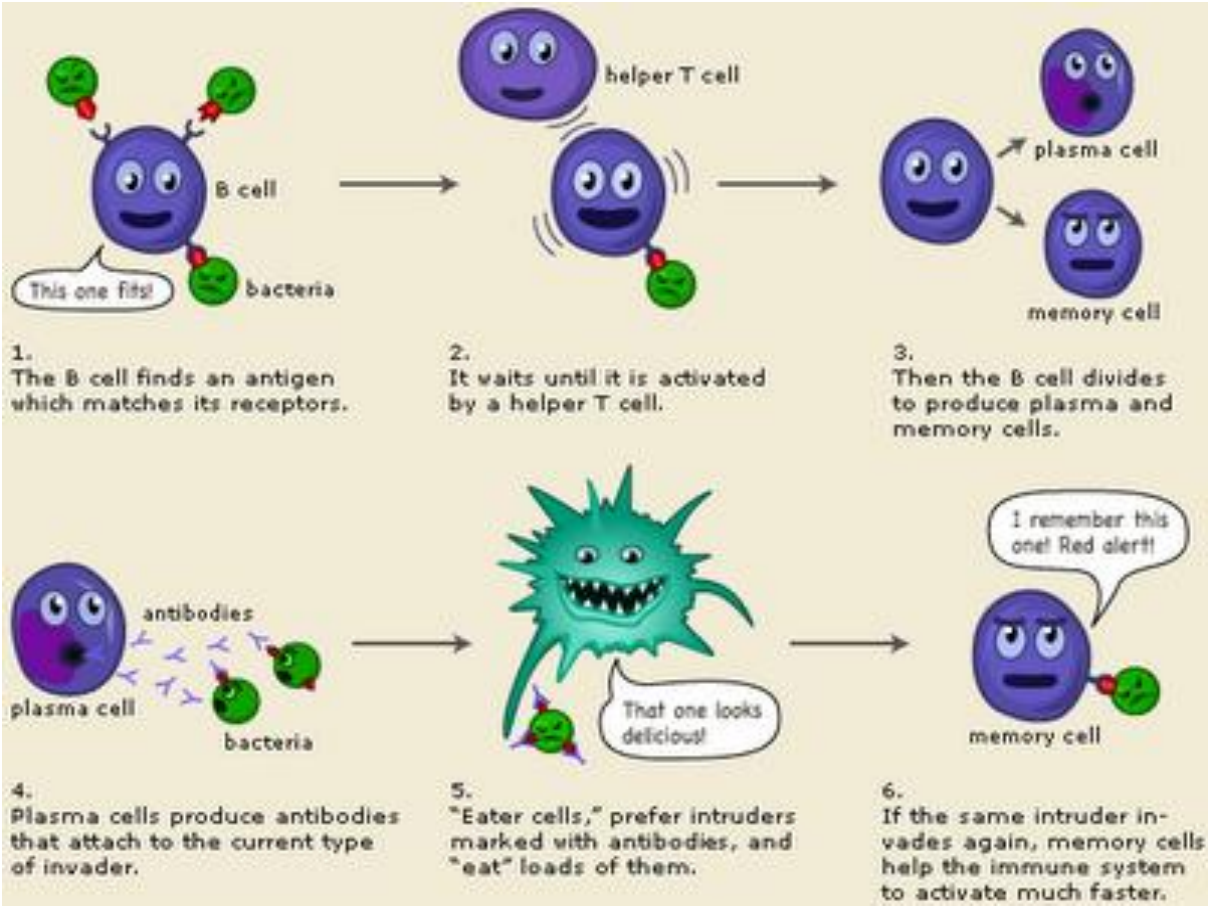
2 Types of Specific Immunity

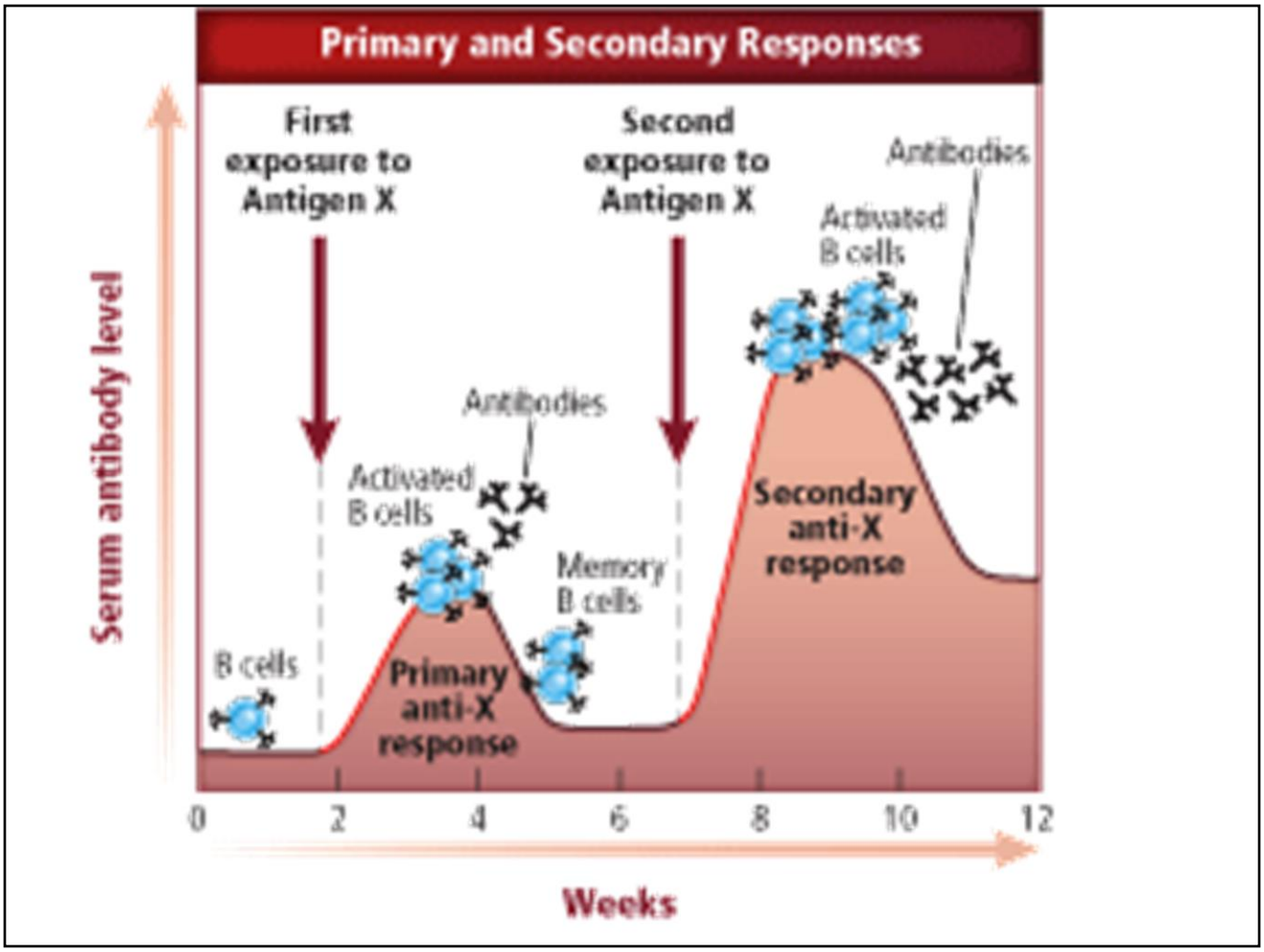
- 1. Cell-Mediated Response
  - Cytotoxic T cells (White Blood Cell type)
  - Target intracellular pathogens
  - Signaled by antigens (anything that acts as a signal to "non-self" by immune cells)



2 Types of Specific Immunity

- 2. Humoral Response
  - B cells (White Blood Cell type)
  - Produce Antibodies & memory B cells
  - Antibodies specific to each different antigen!
    - Protein markers (Immunoglobulins)
  - Second exposure to same antigen results in a more rapid and enhanced immune response because memory B cells are ready!





Explain the graph

Antibodies are proteins. Explain why this macromolecule is best suited for this function.

1. Acquired Immunodeficiency Syndrome (AIDS) is caused by the HIV virus which targets & destroys Helper T cells. Which of the following is least likely to be affected in a person with AIDS.
    a. Their antibody levels
    b. Their inflammatory response
    c. Their cytokine production
    d. Their Cytotoxic T cell levels

2. The RAS-3 gene encodes an immune protein that can kill a wide range of bacteria. Its gene sequence is similar across domains & most animals, plants & fungi possess this gene and produce these proteins. Which statement best describes the rationale behind this finding?
    a. This specific form of immunity were passed down from a common ancestor.
    b. These proteins must be antibodies.
    c. Certain bacteria must have been pathogenic in a common ancestor and this innate immunity strategy was beneficial.
    d. All of these organisms developed a similar gene independently that provided a successful innate form of defense.

3. A person feels an illness coming on after having been sick already just about 1 month ago. She goes to the doctor, her antibody serum level is checked & compared to her test from the last time she was sick. Which of the following test results would make it likely that her symptoms will be similar to the previous one but shorter in duration?
    a. Her Helper T cell count will be the same as the previous test.
    b. Her antigen level will be higher than the previous test.
    c. Her Cytotoxic T cell count will be lower than the previous test.
    d. Her antibody level will be higher than the previous test.

Feedback Mechanisms to Reestablish Homeostasis after Disruptions

- Organisms use feedback mechanisms to maintain their internal environments and respond to environmental changes.

Negative Feedback: A stimulus causes a condition to change and then some mechanism leads to the altered condition to go back to normal. The mechanism leads to a **decrease in undesirable change** until a set-point is reached.

Positive Feedback: A stimulus causes a condition to change and then some mechanism leads to an increase in the altered condition. The mechanism leads to an **increase in a desirable change** until a set-point is reached.

Many pathways are coordinated by **hormones**. Other pathways are coordinated by non-hormone molecules like cytokines in the immune system & cyclins during cell division.

Negative Feedback Pathways

1. **Abscisic Acid (ABA)** is released in response to drought in plants. ABA causes stomata to close to prevent further water loss until normal water balance is restored.
2. **Insulin** is secreted when blood glucose levels are high, causing surrounding tissue to take in the excess glucose out of the blood & form large storage carbohydrates until normal blood glucose levels are restored.
3. **Melatonin** is secreted in response to darkness, causing a decrease in metabolic rates until daylight returns.
4. **T3 & T4** activated by **TSH** in response to a need for increased metabolism. Metabolism increases until a set point which triggers TSH production to stop.
5. **ADH** is released in response to low blood volume/dehydration. ADH dilates kidney tubules allowing water to be reabsorbed faster, increasing blood volume until a set point.

Positive Feedback Pathways

1. **Auxin** is released in response to sunlight in plants. Auxin causes the cells opposite the light to elongate rapidly, causing a bending effect in the stem. More elongated cells produce more auxin, stimulating a continuous elongation of cells until completed.
2. **Ethylene** is released by ripening fruit. Increasingly ripened fruit triggers more ethylene production until the ripening process is complete.
3. **Oxytocin** causes uterine contractions in labor and contractions stimulate more production of oxytocin until the process of child birth is complete.
4. **LH** causes an egg to develop in a follicle and the follicle stimulates more LH production until the egg ruptures through the follicle during ovulation.
5. A laceration triggers blood, platelets & **clotting factors**. Clotting factors trigger more clotting factors to arrive and form a clot/scab over the laceration until it is sealed.

1. Which of the following correctly describes a relationship between two different feedback mechanisms?
    a. The Oxytocin & LH mechanisms could interfere with each other.
    b. The ABA & Ethylene mechanisms could interfere with each other
    c. The TSH & Insulin mechanisms could interfere with each other.
    d. ADH & ABA mechanisms could interfere with each other.

2. Plants & animals have a variety of hormones for different functions. Which pair of hormones represents a similar feedback mechanism & outcome among plants & animals?
    a. Auxin & Oxytocin
    b. Ethylene & Insulin
    c. ABA & ADH
    d. Oxytocin & LH

Animal Behavioral Responses

- Learned behavior: Occurs through interactions with the environment and other organisms
  - Prey selection -Community Ranks
- Innate behavior: Inherited/Genetic
  - Babies Cry & Suckle
  - Animal Courtship (birds, insects)
- These behaviors can often be passed to offspring making them subject to natural selection

Provide 3 examples of animal behavior justified based on natural selection.

Can you think of any behaviors that defy natural selection?

Provide 4 examples of cooperativity among organisms that contribute to ecosystem stability.